

CLAIMS

1. An image display device that projects, via a relay optical system, the light emitted from a first two-dimensionally light emitting type photoelectric device which is perpendicular to the light beam emitting direction onto first and second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that the center distance between said first and second light diffusing bodies is within 5.5 to 7.5 cm, in that said first and second eyepiece optical systems are each constituted by at least two lenses composed of, sequentially from the eyeball's crystalline lens side, one or more convex lens(es) and a cemented lens, in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < 0$, in that the cemented portion of said cemented lens is made a convex surface on the side of said light diffusing body, and in that the color dispersion of the light diffusing body side lens of said cemented lens is made larger than that of the other lens thereof.
2. An image display device that projects, via a relay optical system, the light emitted from a first two-dimensionally light emitting type photoelectric device which is perpendicular to the light beam emitting direction onto first and second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that the center distance between said first and second light diffusing bodies is within 5.5 to 7.5 cm, in that said first and second eyepiece optical systems are each constituted by at least two lenses composed of, sequentially from the eyeball's crystalline lens side, one or more convex lens(es) and a cemented lens, in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < 0$, in that the cemented portion of said cemented lens is made a concave surface on the side of said light diffusing body, and in that the color dispersion of the light diffusing body side lens of said cemented lens is made smaller than that of the other lens thereof.

3. An image display device that projects, via a relay optical system, the light emitted from a first two-dimensionally light emitting type photoelectric device which is perpendicular to the light beam emitting direction onto first and second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that the center distance between said first and second light diffusing bodies is within 5.5 to 7.5 cm, in that said first and second eyepiece optical systems are each constituted by at least two lenses composed of, sequentially from the eyeball's crystalline lens side, one or more convex lens(es) and a cemented lens, in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < 0$, in that said cemented lens has at least two cemented portions, in that the cemented surface located near to said light diffusing body is made a concave surface on the side of said light diffusing body, in that the other cemented surface is made a convex surface on the side of said light diffusing body, and in that the color dispersion of the center lens bounded by said cemented portions is made larger than those of the other two lenses surrounding the center lens.
4. An image display device that projects, via a relay optical system, the light emitted from a first two-dimensionally light emitting type photoelectric device which is perpendicular to the light beam emitting direction onto first and second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that the center distance between said first and second light diffusing bodies is within 5.5 to 7.5 cm, in that said first and second eyepiece optical systems are each constituted by at least two lenses composed of, sequentially from the eyeball's crystalline lens side, one or more convex lens(es) and a cemented lens, in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < 0$, in that said cemented lens has at least two cemented portions, in that the cemented surface located near to said light diffusing body is made a convex surface on the side of said light diffusing body, in that the other cemented surface is made a concave surface on the side of said light diffusing body, and

in that the color dispersion of the center lens bounded by said cemented portions is made smaller than those of the other two lenses surrounding the center lens.

5. An image display device according to any one of claims 1-4, characterized in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < -1$.

6. An image display device that projects, via a relay optical system, the light emitted from a first two-dimensionally light emitting type photoelectric device which is perpendicular to the light beam emitting direction onto first and second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that the center distance between said first and second light diffusing bodies is within 5.5 to 7.5 cm, in that said first and second eyepiece optical systems are each constituted by at least two lenses composed of, sequentially from the eyeball's crystalline lens side, one or more convex lens(es) and a cemented lens, in that the cemented portion of said cemented lens is made a convex surface on the side of said light diffusing body, in that the color dispersion of the light diffusing body side lens of said cemented lens is made larger than that of the other lens thereof, and in that said light diffusing body is made a curved surface having a concave surface shape toward said cemented lens.

7. An image display device that projects, via a relay optical system, the light emitted from a first two-dimensionally light emitting type photoelectric device which is perpendicular to the light beam emitting direction onto first and second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that the center distance between said first and second light diffusing bodies is within 5.5 to 7.5 cm, in that said first and second eyepiece optical systems are each constituted by at least two lenses composed of, sequentially from the eyeball's crystalline lens side, one or more convex lens(es) and a cemented lens, in that the cemented portion of said cemented lens is made a concave surface on the side of said light diffusing body, in that the color dispersion of the light

diffusing body side lens of said cemented lens is made smaller than that of the other lens thereof, and in that said light diffusing body is made a curved surface having a concave surface shape toward said cemented lens.

5 8. An image display device according to claim 6 or 7, characterized in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < 0$.

9. An image display device according to claim 8, characterized in that at least one surface of the lens surfaces of said convex lens(es) is a conic surface with conic constant $K < -1$.

10 10. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that the distance between the optical centers of said first and second eyepiece optical systems and the distance between the centers of the projected images on said first and second light diffusing bodies are made adjustable so that those two distances are equal to the eye-width.

15 11. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that said relay optical system makes the projection magnification of the image of said first photoelectric device projected onto said light diffusing bodies variable, in that said relay optical system is a non-telecentric system in which the principal ray of each light beam incident on said light diffusing bodies changes from of a diverging direction type to of a converging direction type when the projection magnification changes from a magnifying magnification to a reducing magnification, and in that the principal rays that are emitted from said light diffusing bodies and reach the pupil of said eyeball are inclined toward the converging direction when the principal rays are emitted from said light diffusing bodies.

20 12. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that said light diffusing bodies that diffuse light are a transmission type diffusing plate constituted by a transmission plate on which abrasive grains of a metal oxide or metallic carbide of which grain diameter is precisely controlled with micron-grade are coated.

30 13. An image display device according to claim 12, characterized in that said abrasive grains are made of at least one of silicon carbide, chromium oxide, tin oxide, titanium oxide, magnesium oxide, and aluminum oxide and in that said transmission plate is a polyester film.

35 14. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that it has a second two-dimensionally light emitting type photoelectric device that is arranged such that the light beams thereof are perpendicular

to those of said first photoelectric device and also has, in said relay optical system, which projects the light emitted from said first photoelectric device onto said light diffusing bodies, a light divider that divides the light beams and leads them to said first and second light diffusing bodies, in that the light beams from said second photoelectric device are made incident on said light divider such that the light beams are perpendicular to the light beams emitted from said first photoelectric device, and in that said light divider has a function to divide the light from said first photoelectric device from the light from said second photoelectric device and also to combine the divided light beams of said first photoelectric device with the divided light beams of said second photoelectric device and lead them to said first light diffusing body and to said second light diffusing body, respectively.

15. An image display device according to claim 14, characterized in that the difference between the number of reflections by mirrors experienced by the light beams emitted from said first photoelectric device from the first reflection by a mirror up to reaching the user's eyes and the number of reflections by mirrors experienced by the light beams emitted from said second photoelectric device from the first reflection by a mirror up to reaching the user's eyes is 0 or an even number.

16. An image display device according to claim 14, characterized in that the difference between the number of reflections by mirrors experienced by the light beams emitted from said first photoelectric device from the first reflection by a mirror up to reaching the user's right eye and the number of reflections by mirrors experienced by the light beams emitted from said first photoelectric device from the first reflection by a mirror up to reaching the user's left eye is 0 or an even number and in that the difference between the number of reflections by mirrors experienced by the light beams emitted from said second photoelectric device from the first reflection by a mirror up to reaching the user's right eye and the number of reflections by mirrors experienced by the light beams emitted from said second photoelectric device from the first reflection by a mirror up to reaching the user's left eye is 0 or an even number.

17. An image display device according to claim 14, characterized in that the distance between the optical centers of said first and second eyepiece optical systems and the distance between the centers of the projected images on said first and second light diffusing bodies are made adjustable so that those two distances are equal to the eye-width and in that an optical path length adjusting mechanism that adjust, when the two distances, the distance between the optical centers of the eyepiece optical systems and the distance between the centers of the projected images, are adjusted, the optical path length from said first photoelectric device to the user's eyes and the optical path

length from said second photoelectric device to the user's eyes so that each of them does not change is provided.

18. An image display device according to claim 14, characterized in that said relay optical system, which projects the light emitted from said first photoelectric device onto said light diffusing bodies, makes the projection magnification relative to said light diffusing bodies of the light beams projected onto said light diffusing bodies variable and in that an illuminance varying mechanism for making, when the magnification is varied, the illuminances of the respective pictures projected from said first photoelectric device and said second photoelectric device onto said light diffusing bodies substantially equal to each other is provided.

19. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that said first photoelectric device is a transmission type or reflection type liquid crystal device element and has three pieces of liquid crystal devices, each corresponding to each of the colors of G, B, and R, and an illumination system that illuminates said liquid crystal devices and in that said illumination system is a uniformizing optical system that uniformizes the outputs from light emitting LEDs of G, B, and R.

20. An image display device according to claim 19, characterized in that said uniformizing optical system has, for each of the LEDs of G, B, and R, a plurality of high intensity LEDs, collects the lights from those plurality of LED light emitting portions by using optical fibers, and illuminates said liquid crystal device with the collected lights.

21. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that said first photoelectric device is a transmission type or reflection type liquid crystal device element and has three pieces of liquid crystal devices, each corresponding to each of the colors of G, B, and R, and an illumination system that illuminates said liquid crystal devices and in that said illumination system is cold cathode tubes of G, B, and R.

22. An image display device according to claim 21, characterized in that said uniformizing optical system has, for each of the colors of G, B, and R, a plurality of cold cathode tubes, collects the lights from those plurality of cold cathode tubes by using optical fibers, and illuminates said liquid crystal device with the collected lights.

23. An image display device according to any one of claims 1-4, claim 6, and claim 7, characterized in that at least a portion of said image display device is supported by a portion other than a user, is also in contact with the face of said user, and is made movable in response to the movement of the face of said user.

24. An image display device which has an optical system that has at least, relative to each of the right and left eyeballs, portions independent of each other and which projects an image into each of said right and left eyeballs, said image display device being characterized in that said independent portions are each constituted by at least two
5 lenses composed of, sequentially from said eyeball side, one or more convex lens(es) and a cemented lens and in that the surface, located distant from the eyeball, of the convex lens, among said convex lenses, located nearest to the eye ball is made a conic surface with conic constant $K < 0$.
25. An image display device according to claim 24, characterized in that said
10 cemented lens is provided, in the independent portion of said optical system, on the nearest side of an image forming surface forming said image.
26. An image display device characterized in that it has, instead of the first photoelectric device according to any one of claims 1-4, claim 6, and claim 7, two
15 two-dimensionally light emitting type photoelectric devices which are perpendicular to the light beam emitting direction and in that it is configured such that, instead of projecting, via said relay optical system, the light emitted from said first photoelectric device onto said first and second light diffusing bodies which are independent of each other relative to the right and left eyes, the lights emitted from said two photoelectric devices are each projected, via said relay optical system, onto said first and second light
20 diffusing bodies which are independent of each other relative to the right and left eyes.
27. An image display device according to claim 26, characterized in that the distance between the optical centers of said first and second eyepiece optical systems and the distance between the centers of the projected images on said first and second light diffusing bodies are made adjustable so that those two distances are equal to the
25 eye-width and in that an optical path length adjusting mechanism that adjust, when the two distances, the distance between the optical centers of the eyepiece optical systems and the distance between the centers of the projected images, are adjusted, the optical path lengths from said two photoelectric device to the user's eyes so that each of them does not change is provided.
- 30 28. An image display device according to claim 26, characterized in that said relay optical system, which projects the lights emitted from said two photoelectric devices onto said light diffusing bodies, makes each of the projection magnifications relative to said light diffusing bodies of the light beams projected onto said light diffusing bodies variable and in that an illuminance varying mechanism for making, when the
35 magnifications are varied, the illuminances of the respective pictures projected from said two photoelectric devices onto said light diffusing bodies substantially equal to

each other is provided.

29. An image display device that projects, via a relay optical system, each of the lights emitted from two two-dimensionally light emitting type photoelectric devices which are perpendicular to the light beam emitting direction onto first and second light
5 diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more,
10 said image display device being characterized in that said two two-dimensionally light emitting type photoelectric devices are each a reflection type liquid crystal device element, in that one light source, a first polarization beam splitter that divides the light emitted from said light source into P-polarized light and S-polarized light, and an optical system that leads each of the P-polarized light and S-polarized light respectively
15 to said two two-dimensionally light emitting type photoelectric devices, thus illuminates said two two-dimensionally light emitting type photoelectric devices, and leads the lights reflected thereby to said relay optical system are provided, and in that said optical system leads said P-polarized light and S-polarized light to said two-dimensionally light emitting type photoelectric devices via a second polarization beam splitter and a $\lambda/4$
20 plate and leads the lights reflected thereby to said relay optical system via said $\lambda/4$ plate and second polarization beam splitter.

30. An image display device that projects, via a relay optical system, each of the lights emitted from two sets of two-dimensionally light emitting type photoelectric devices which are perpendicular to the light beam emitting direction onto first and
25 second light diffusing bodies which are independent of each other relative to the right and left eyes and projects and images the transmitted images of said light diffusing bodies, via first and second eyepiece optical systems which respectively correspond to the first and second light diffusing bodies, onto the retina in the eyeball, with the imaged transmitted images being a wide range image having a field of view angle of ± 22.5 degrees or more, said image display device being characterized in that said two
30 sets of two-dimensionally light emitting type photoelectric devices are each constituted by three reflection type liquid crystal device elements, each corresponding to each of the colors of G, B, and R, in that one light source, a first polarization beam splitter that divides the light emitted from said light source into P-polarized light and S-polarized
35 light, and an optical system that leads each of the P-polarized light and S-polarized light respectively to said two sets of two-dimensionally light emitting type photoelectric

devices, thus illuminates said two two-dimensionally light emitting type photoelectric devices, and leads the lights reflected thereby to said relay optical system are provided, and in that said optical system leads said P-polarized light and S-polarized light to said two-dimensionally light emitting type photoelectric devices, which accommodate the colors of G, B, and R, via a second polarization beam splitter, a $\lambda/4$ plate, and an RGB light beam division multiplexer prism and leads the lights reflected thereby to said relay optical system via said RGB light beam dividing/multiplexing prism, said $\lambda/4$ plate, and said second polarization beam splitter.

5 31. An image display device according to claim 29 or 30, wherein said light source is a plurality of white light LEDs two-dimensionally arranged in an array form.

10 32. An image display device according to claim 29 or 30, characterized in that said light source has a group of R color LEDs, a group of G color LEDs, and a group of B color LEDs, each being constituted by a plurality of the respective color LEDs two-dimensionally arranged in an array form, and an RGB light beam division multiplexer prism that combines the lights emitted by those groups.

15 33. An image display device according to claim 29 or 30, characterized in that the optical system, which leads the light emitted from said light source to said two-dimensionally light emitting type photoelectric devices, has an illumination uniformizing optical system.

20 34. An image display device according to claim 33, characterized in that said illumination uniformizing optical system is at least one rod and in that the final exit plane of said rod and the surface of said two-dimensionally light emitting type photoelectric devices are made substantially conjugate with each other.